The birds of Tubbataha Reefs Natural Park and World Heritage Site, Palawan province, Philippines, including accounts of breeding seabird population trends

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Data on the seabird population of Tubbataha Reefs Natural Park, Palawan province, Philippines, which lies in the Sulu Sea, date back to 1911. However, regular surveys and monitoring began only in 1997 and have resulted in a wealth of new information. An annotated list of the 106 recorded species is presented and changes in the population of the seven breeding seabird species and the factors that influence such changes are discussed. From an estimated 13,500 breeding seabirds in 1981, the population decreased to less than a third of that number in 2003, with the only Philippine population of Masked Booby *Sula dactylatra* being extirpated in 1995. Thanks to strict enforcement of a no-visitor policy from 1997, the population increased to around 32,300 birds in 2013. The park is the only known breeding area of the subspecies *worcesteri* of Black Noddy *Anous minutus*. It hosts the largest breeding colonies of Brown Booby *Sula leucogaster*, Greater Crested Tern *Thalasseus bergii* and Brown Noddy *A. stolidus*, and the second-largest populations of Red-footed Booby *Sula sula* and Sooty Tern *Onychoprion fuscatus*, in the Philippine archipelago. Data on other breeding sites of these species in the archipelago are included. Two new species for the Philippines, 14 new species for Palawan province and four globally threatened species, including the Critically Endangered Christmas Frigatebird *Fregata andrewsi*, together with first Philippine records of Yellow Wagtail *Motacilla flava tschutschensis* and *M. f. macronyx* are described. Since 1981 there has been a reduction in land area of over 40%, but the previously barren islets are now vegetated and this has encouraged expansion of tree-nesting Red-footed Booby and Black Noddy colonies to the detriment of Brown Booby. Temperature anomalies caused by El Niño and La Niña events appear to affect the breeding cycle of seabirds.

INTRODUCTION

The uninhabited Tubbataha Reefs Natural Park lies in the Sulu Sea, 170 km south-east of Puerto Princesa City, Palawan province, Philippines. The area was designated a protected national marine park in 1988 and as a natural marine park in 2006. The protected area was expanded to include the Jessie Beazley Reef in 2010. It was declared a UNESCO World Heritage Site in 1993 and in 1999 was included in the Ramsar list of Wetlands of International Importance (Ramsar 2016, UNESCO 2016).

There have been few studies of birds in the Sulu Sea and published data on the avifauna of the atolls and islets are largely based on the collection of specimen or sight records from a century ago. Early collectors included Richard McGregor in January 1903 and Dean Worcester, who visited the Tubbataha Reefs in June 1911 and provided the first description of its seabird colony (McGregor 1904, Worcester 1911). No further ornithological surveys were undertaken in this area until a survey by the Haribon Foundation for Conservation of Natural Resources in 1981 (Kennedy 1982). More recent studies have included surveys of the population of Brown Booby *Sula leucogaster* (NRMC 1983, Cruz & White 1989, Arquiza & White 1999) and full surveys of the breeding bird population in 1991, 1993 and 1995 (Heegaard & Jensen 1992, Magsalay & Toledo 1993, Manamtam 1996). Between 1997 and 2004, WWF-Philippines made several inventories of the seabird populations (Sabater 2002, Sabater *in litt.* 2004). From 2004 until the present day the Tubbataha Reefs Natural Park management office has carried out regular monitoring and made quarterly inventories of the seabirds. Comprehensive surveys, assisted by independent expert ornithologists, have mainly taken place in May each year (Jensen 2004a, 2005, 2006, 2009, 2010, 2011, 2012, 2013) and are ongoing; this study covers the period up to the end of 2013.

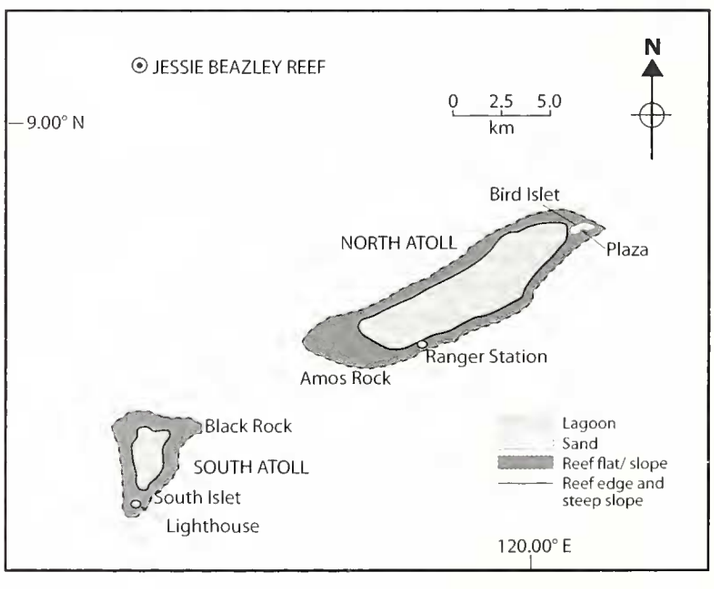
Effective conservation management involving the restriction of access and use of resources from the park started only in 1997. Prior to that, between the early 1960s and early 1990s, local fishermen from the Cagayancillo islands, Palawan, stayed for up to a month on the islets to fish and collect sea-turtles, seabirds, and their eggs, mainly between April and July. By the early 1980s, increasing use of motorboats had brought larger numbers of fishermen from other provinces and other countries, together with the introduction of cyanide and dynamite fishing techniques. Commercial scuba diving started in 1979 and within a few years the remote reefs were transformed into a priority destination for local and international scuba divers (Arquiza & White 1999, Songco 2003, Dygico 2006). Today the dive season is restricted to three months (mid-March to mid-June), whilst permits and entrance fees provide the necessary funds to manage and patrol the park.

STUDY AREA

The 97,000 ha Tubbataha Reefs Natural Park, lying between 8.761°N 119.844°E and 9.052°N 119.817°E, includes the North and South Atolls and the Jessie Beazley Reef (Figure 1). The total exposed area of these formations at high tide is about 14,000 m^2.

Bird Islet, previously known as North Islet (Plate 1), located in the North Atoll (8.931°N 119.997°E), had a circumference of

Figure 1. Location of Tubbataha Reefs Natural Park, Sulu Sea. Source: Arquiza & White (1999).



TERI AQUINO

Plate 1. Aerial photograph of Bird Islet (formerly named North Islet), 25 April 2012.

TERI AQUINO

Plate 2. Aerial photograph of South Islet, 5 September 2005.

548 m measured along the vegetation line and average high-tide mark, with a land area of 10,936 m^2 in 2013 (Jensen 2013). The dominant natural vegetation is beach-forest, although about 65% of the islet is an open barren area with an influx of grasses. This area, known as the Plaza, is the historical breeding site of ground-nesting seabirds.

The circumference of the tiny South Islet, area 2,860 m^2, in the South Atoll (8.749°N 119.820°E) is 230 m (Jensen 2013). It was originally part of a large sandbar but a lighthouse, protected by a concrete seawall, was constructed in 1978 (Plate 2). Construction of the seawall led to the growth of beach-forest vegetation, including about 100 trees, several of them now up to about 9 m tall.

Jessie Beazley Reef (9.052°N 119.817°E) is submerged at high tide. At average tides, the exposed area—coral pebbles without vegetation—is about 350 m^2. Birds have also been recorded on Amos Rock, North Atoll (8.850°N 119.900°E) and Black Rock, South Atoll (8.804°N 119.845°E); both are large coralline boulder and sand deposits, exposed at low tide. A large bare sandbar at North Atoll, where the park ranger station is located (8.851°N 119.917°E), also hosts congregations of birds.

METHODS

The Tubbataha Reefs Natural Park management authority has established a monitoring protocol for seabirds. In 2004, comprehensive training of park rangers and staff from the Tubbataha Management Office was undertaken, focused on identification, monitoring and survey techniques of breeding seabirds, based on Bibby *et al.* (2000). Since then, quarterly direct counts of the breeding seabird populations, supplemented by regular distance population monitoring, have become a routine part of the park rangers' activities. Annual supervision and identification of other bird species is carried out by an independent visiting ornithologist. The supervisory function, mainly carried out in early May, includes a review of the rangers' monitoring data and an in-depth inventory focused on the breeding seabird populations. The overall seabird population is determined by a combination of direct counts of adults, immature and juvenile birds, and square counts of ground-nesting species including nests, eggs, pulli and juveniles. In addition, in-flight counts, mainly of boobies and frigatebirds, are made between 16h30 and 18h30 (dusk), when most birds congregate and start roosting. Equipment used includes binoculars, spotting-scopes, GPS and digital camera.

Distance population monitoring is normally carried out in the morning on a monthly basis from a boat cruising 50–70 m parallel to the shoreline, at both Bird and South Islets, and includes two or three independent estimated counts of all visible seabirds. The averaged results are used to determine the population variation trends throughout the year. A total of 91 distance population counts were carried out between April 2004 and May 2013.

Of the 66 inventories made on behalf of various organisations between 1981 and November 2013, 13 were between January and March, 31 from April to June, 9 from July to September and 13 from October to December. Most survey effort (69%) was put in between 2005 and 2013 and in this period the inventories were made between 13 April and 10 June, mostly from 5 to 10 May.

All datasets from 1981 to 2013 were used in the analysis of seabird population trends, and the dataset from June 1981 (Kennedy 1982), taken in late afternoon when most of the populations were present, was used as the baseline to determine population trends. The aggregate counts of populations present on the islets during the day and the birds returning in the late afternoon were used to determine the total breeding population of Red-footed Booby *Sula sula* and Brown Booby. Data from the evening in-flight counts of returning Red-footed and Brown Booby were averaged for the period 2004 to 2013; for Red-footed Booby, 59.3% of the adult population was away during the day, and 37.3% for Brown Booby. Appropriate adjustments were made to daytime counts made prior to 2004 (Magsalay 1993, Manamtam 1996, Sabater 2002, *in litt.* 2004) to facilitate the evaluation of changes to the two species's populations. Analysis of the in-flight averages using ANOVA (two-factor without replication) revealed that the difference between years was not statistically significant ($p = 0.024281$) within species and age groups. Thus, extrapolation of in-flight percentages from 2004 to 2013 to the daytime data of earlier years when no in-flight counts were made was done without compromising the integrity of the datasets.

The results of the seabird inventories collected during the main breeding season from April to June were compared with the datasets from other months to estimate the total annual seabird populations. In addition to the counts of seabirds, changes in their habitat use were monitored, with habitat changes being analysed from data collected on the number and status of bushes and trees. From 2004 land areas have been calculated at high tide each year using GPS measurements and changes recorded.

RESULTS

A total of 106 species has been recorded from the Tubbataha Reefs Natural Park, of which 11 species breed or are known to have bred, 35 species are Philippine residents or species with both resident and migratory status, and 60 species are migratory. A complete annotated list of the birds recorded in the park is given in Appendix 1.

Accounts of the breeding species, and other species of particular interest, are given below; land area and habitat changes observed during the survey period and the consequences for the avian species of the park are reviewed in the discussion section.

Selected species accounts

Species marked † are new records for the Philippines and species marked * are not listed for Palawan province by Dickinson *et al.* (1991) or Kennedy *et al.* (2000).

Breeding species

The following 11 species are known to breed or to have bred in the Tubbataha Reefs Natural Park.

* Barred Rail *Hypotaenidia torquata*

First records 5 and 6 May 2003, two adults on both Bird Islet and South Islet. It is believed to breed regularly on Bird Islet, a pair with a nest containing five eggs was found there on 30 July 2005; also seen there in 2013.

Green-backed Heron *Butorides striata*

First record 6 May 2004, bred irregularly on Bird Islet and South Islet in 2004, 2006, 2007, 2012 and 2013. Evidence of breeding was found on South Islet, 7 May 2007, when a pair was recorded at a nest (Jensen 2007).

Pacific Reef Egret *Egretta sacra*

First record 24 October 1991, 40 birds (Heegaard & Jensen 1992). Typically 7 pairs breed annually, on both Bird and South Islets; nests hold up to five eggs. Of 108 observations, 92 were dark morph birds. Outside the breeding season inter-island movements may occur (e.g. 40 birds present in October 1991, 39 in October 2006).

Masked Booby *Sula dactylatra*

Tubbataha Reefs formerly held the only known Philippine breeding population of this species (Dickinson *et al.* 1991, Kennedy *et al.* 2000). Worcester (1911) discovered a large colony on Bird Islet on 29 June 1911, whilst in June 1981 Kennedy (1982) estimated 150 adults were present. Anthropogenic pressures, including egg and fledgling collection, caused a terminal population decline (Arquiza & White 1999, Songco 2003). In April 1989 a minimum of 30 adults were recorded (Arquiza & White 1999), whereas on 26 October 1991 only 5 adults and 1 immature were present (Heegaard & Jensen 1992) and as late as April 1993 two fledglings were confiscated from a fishing boat (Palaganas & Perez 1993). The last park record (Plate 3) was of one adult on 23 June 1995 (A. Manamtam pers. comm. 1996). The species is now extirpated from the Philippines; the last known record was an immature at sea off Camiguin Island, Cagayan, Luzon, September 2002 (I. Sarenas *in litt.* 2004).

Plate 3. The last Masked Booby *Sula dactylatra* at Bird Islet, May 1995.

J. M. L. TAN

Red-footed Booby *Sula sula*

The first record for the park, involving eight non-breeding adults, was from South Islet on 15 June 1981 (Kennedy 1982) and this was followed by the first record from Bird Islet on 25 October 1991 (Heegaard & Jensen 1992). There were no further records on either islet until 2000 when two adults were recorded on Bird Islet, followed by 44 in 2001 and 43 in 2002, when three pairs nested for the first time. A breeding colony was established on Bird Islet in April 2004, when there was a huge influx of 2,435 adults, and 931 nests were counted. The following year 4,083 adults and 913 nests were counted; numbers then remained in the range 2,500–2,900 until October 2009 when they peaked at 7,047. The birds nested in all the available suitable trees and vegetation, sometimes near ground-level but, since the start of colonisation, all mature trees used by the species have died due to loss of foliage—used for nest-building—and the effect of the birds' faeces. Colonisation of South Islet did not start until October 2009 (Heegaard & Jensen 1992, Manamtam 1996, Sabater 2002, Jensen 2004a, 2005, 2007, 2009); in May 2010, 90 adults with six nests were counted, whilst in May 2013, 593 adults with 279 nests were counted (Jensen 2013)

Data collected by park rangers between 2004 and 2013 confirmed that the species breeds throughout the year (Table 1, Figure 2), although more nests are found between October and December than earlier in the year, e.g. 931 nests in November 2004 and 1,125 nests in October 2009. The largest numbers of pulli recorded were 472 in October 2008 and 482 in August 2011. In November 2013, 2,975 adults were counted on Bird Islet, with 494 nests. Data from other colonies indicate that the incubation period is about 45 days and time to fledging 100–140 days (Carboneras *et al.* 2016); birds generally breed once annually, although seasons may be missed, particularly during El Niño years. The total annual breeding population is estimated to lie between 7,000 and 7,500 adults.

Table 1. Red-footed Booby 1981–2013. Maximum counts of adults and nests per year.

	1981	1991	1992	1993	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Adults	8	1	0	0	0	0	0	0	2	44	43	20	2,435	4,083	2,625	2,902	2,513	7,047	2,331	3,738	4,487	3,507
Nests	0	0	0	0	0	0	0	0	0	0	3	2	931	913	645	619	710	1,125	459	580	739	848

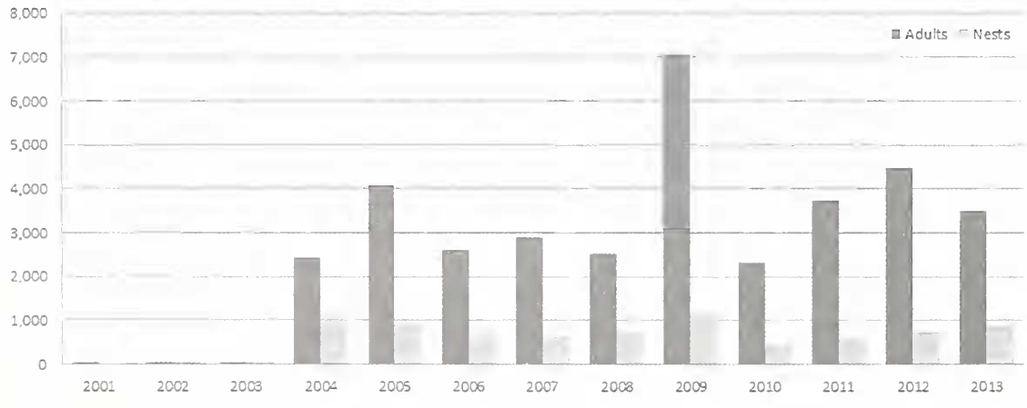


Figure 2. Red-footed Booby population changes and nesting records 2000–2013.

Other Philippine breeding sites: the species is known to breed at three other sites: Cawili Island, Cagayancillo, Palawan (9.482°N 121.036°E), 448 adults (19 nests), 6 May 2007; Bancoran Island, Mapun (formerly Cagayan de Tawi-Tawi), Tawi-Tawi (7.958°N 118.666°E), 4,576 adults (314 nests), 16 May 2007; and Bancauan Reef, Mapun, Tawi-Tawi (7.763°N 118.525°E), 8,206 adults (2,085 nests), 18 May 2007 (Jensen 2007).

Brown Booby *Sula leucogaster*

The first record was from Bird Islet on 29 June 1911, when Worcester (1911) recorded an 'enormous' population there and noted that the species 'covered' South Islet. He also found 'numerous' nesting pairs on Black Rock—the sandbars around this rock have since disappeared and the area is submerged at high tide (Kennedy 1982, Heegaard & Jensen 1992). The only subsequent breeding record on South Islet (16 adults) was in June 1981 (Kennedy 1982). From a count of 3,768 adults in June 1981 (Kennedy 1982), the population declined to an estimated 1,000 in April 1989 (White & Calumpong 1992), followed by a low of 600 in October 1991 (Heegaard & Jensen 1992), then rising to 2,060 in March 1995 (Manamtam 1996) and a high count of 2,402 in 1997 before a new low of 527 in March 1999 (Sabater 2002). It again stood at only 577 in 2002 and, although in May 2005 numbers rose to 1,877 (Jensen 2005), they again fell sharply to around 1,000 between 2006 and 2008. The population gradually increased to a count of 2,155 in 2013, still 43% lower than in 1981 (Table 2) and today the adult population is estimated to be 2,200–2,500 adult birds (Figure 3). The species breeds throughout the year, with the highest counts in November 2011: 588 nests, 167 eggs and 339 pulli, and May 2013: 618 nests, 532 eggs and 28 pulli.

Other Philippine breeding sites: apart from Tubbataha Reefs, the Philippine breeding population is now restricted to Maender Reef, Palawan (8.107°N 118.418°E), 16 adults with five nests on 19 May 2007, and Bancauan Reef, Mapun, Tawi-Tawi, six adults with two nests on 16 May 2007. Information from the Philippine Navy indicates that it may still breed on Lawak Island, Kalayaan Islands, Palawan, but only in small numbers (A. Bundgar pers. comm. 2005, A. Arca pers. comm. 2006). It is extirpated from Bancoran Reef (Jensen 2007) where it had bred in large numbers (Worcester 1911) and no is longer found at Didicas Rock, Cagayan, Luzon (Allen *et al.* 2006).

Greater Crested Tern *Thalasseus bergii*

First recorded in June 1911 by Worcester (1911), who reported large groups with eggs on Bird Islet. He did not visit South Islet but instead found the species breeding in large numbers on nearby Black Rock. In June 1981, when Kennedy counted 1,132 eggs (corresponding to 2,264 adults), the species bred only on South Islet, but abandoned the islet as a breeding site during the 1980s when the main location, a large barren sandbar, gradually submerged. Breeding on South Islet was recorded again in 1995 and between 2000 and 2003, with 560 adults counted in 2002; since then

Table 2. Brown Booby 1981–2013. Maximum counts of adults and of nests per year.

	1981	1989	1991	1992	1993	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Adults	3,768	1,000	600	2,000	893	2,060	2,402	1,716	527	1,045	850	577	623	847	1,877	1,110	1,016	1,059	1,273	1,442	1,846	1,888	2,155
Nests	Present	Present	299	Present	Present	763	367	225	192	215	69	163	139	117	45	250	89	497	453	513	575	507	618

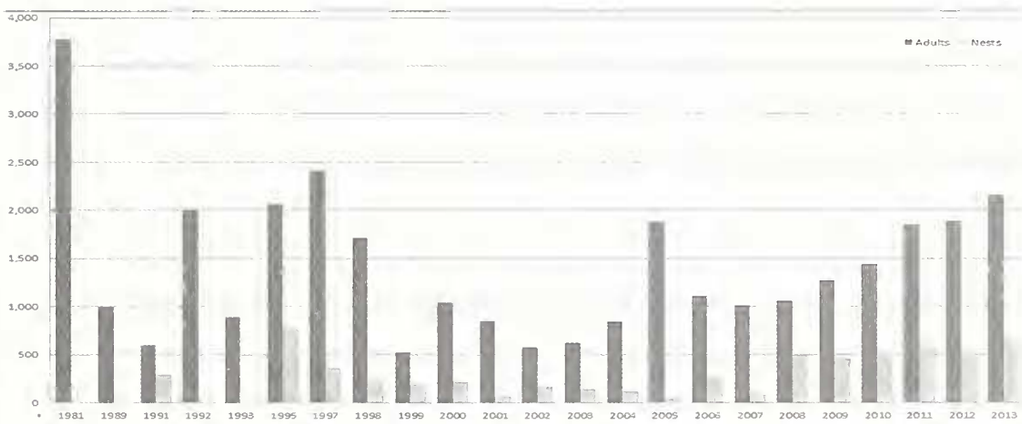


Figure 3. Brown Booby population and highest numbers of nests 1981–2013

Table 3. Greater Crested Tern 1981–2013. Maximum counts of adults and eggs per year.

	1981	1991	1993	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Adults	2,264	100	18	335	15	0	0	2,300	414	4,160	2,064	2,808	7,858	6,894	4,700	6,000	4,433	4,790	6,160	8,653	10,500
Eggs	1,132	0	0	135	0	0	0	97	0	411	109	0	3,929	3,590	521	0	515	2,341	498	1,456	3,939

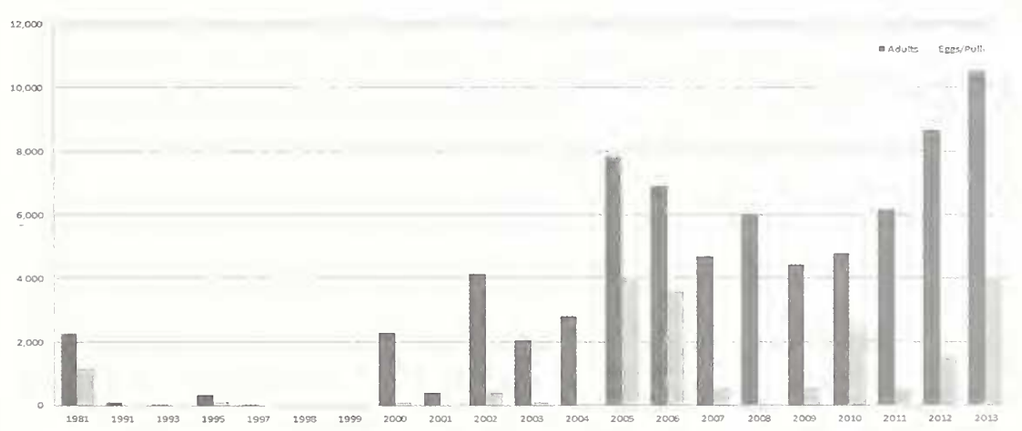


Figure 4. Greater Crested Tern population and highest numbers of eggs 1981–2013.

up to 640 adults have been recorded in May counts but, despite some displaying, there has been no evidence of breeding. In 1981, Kennedy (1982) found no breeding birds on Bird Islet, although the species was present there in 1982, 1989, 1991 and 1993 (NRMC 1983, Heegaard & Jensen 1992, Magsalay & Toledo 1993), but breeding was not recorded until 1995 (Manamtam 1996) or again until August 2000, when 2,300 adults were present with juveniles (Sabater 2002). The population has since fluctuated, although it increased to 9,154 adults with 3,939 eggs in May 2013. The highest number of pulli (2,540) was recorded in July 2006. Overall, the population decreased from 2,264 in 1981 (Kennedy 1982) to only 335 in 1995, but recovered to reach 10,500 adults in August 2013 (Table 3, Figure 4).

Greater Crested Terns breed mainly from May to August and in some years from October to November (2004–2006, 2009). It is generally absent from the park between December and March. From October to December the breeding population is smaller, with a peak count of 2,000 individuals in November 2004. Based on the peak counts of the two breeding populations, the total annual population is estimated to be between 12,000–12,500 adults.

Other Philippine breeding sites: breeding was reported from Maender Reef, Palawan, where numerous groups were noted in June 1911 (Worcester 1911) but not in June 2002 (Sabater 2002); however, in May 2007, 210 adults with four nests were seen (Jensen 2007). The species may breed in small numbers at Sinamahan Cay, Balabac (Matillano *et al.* 2006), but is now extirpated from Bancuan Reef, Mapun, Tawi-Tawi, where more than 100 pairs bred in 1985 (Caretaker M. Bantala pers. comm. 2004).

Sooty Tern *Onychoprion fuscatus*

The first record by Kennedy (1982) was of 35 non-breeding adults on Bird Islet on 13 June 1981; he subsequently reported 5,000 breeding adults on South Islet (Kennedy 1982). It disappeared from South Islet as a breeding species during the 1980s, apparently due to the loss of suitable breeding habitat, and there is only one subsequent breeding record from here, 23 adults on 26 May 2002 (Sabater 2002). On Bird Islet it was reported to be present in 1982 (NRMC 1989) and in October 1991 more than 830 pulli, equivalent to about 1,660 adults, were noted there (Heegaard & Jensen 1991), whilst in March 1995, 455 juveniles were counted among adults (Manamtam 1996). In the 1990s and early 2000s the population on Bird Islet was subject to large fluctuations and the species was largely absent and did not breed in 1998 and 2003, but it has bred continuously there since 2004, albeit in small numbers in some years.

There are two subpopulations of Sooty Terns breeding on Bird Islet: the larger population normally breeds from the end of February to July, whilst a smaller population (absent in 2004, 2006 and 2012), averaging 2,400 individuals, breeds from September to November. The species is usually absent from the park from December to the end of February, except in February 2011 when 1,585 pulli were recorded, indicating that breeding started as early as December the previous year. When adults return to Tubbataha Reefs, they continue to be pelagic by day, settling on land at night for courtship and territorial claims; this continues for 6–7 weeks before egg-laying starts. Since the counts are made during the hours of daylight, the numbers of birds from the beginning of the breeding season may be an under-estimate. The total annual breeding population in peak years is estimated to be 15,000–16,000 adults. The highest spring breeding count was 10,866 adults with 5,515 eggs in May 2010 (Table 4, Figure 5), and the highest autumn breeding count was 4,331 adults in October 2009. In July 2006, 3,100 pulli were counted, with 7,920 adults.

Other Philippine breeding sites: the only other breeding site is Lawak Island, Kalaayan, Palawan (McManus 1994, P. Aliño *in litt.* 2009), where breeding numbers are thought to be greater than at Tubbataha Reefs; in 2005 the seasonal egg harvest was 16 large baskets (A. Bungar pers. comm. 2005).

Brown Noddy *Anous stolidus*

The first record was in June 1911 when Worcester (1911) reported numerous birds nesting on Bird Islet. In June 1981, 1,100 adults were counted there by Kennedy (1982), who also found 518 nests on South Islet. However, in October 1991 Heegaard & Jensen (1992) found only 25 non-breeding birds on Bird Islet and 65 non-breeders on South Islet; in 1993 Magsalay & Toledo (1993) found 200 adults on Bird Islet and 15 on South Islet, whereas in 1996 Manamtam (1996) found about 600 adults on Bird Islet and 43 on South Islet, several of them with nests. On Bird Islet, only 37 bred in 2001, 375 in 2002 but none in 2003. However, from 2004 the species bred annually in increasing numbers, from 216 birds in 2004 to 1,742 in 2011, before declining to 1,163 in 2013. A high count of 573 nests holding 405 eggs was made in May 2013. The species was absent from South Islet in 1998, 1999 and 2001 but, with 40 recorded in 2000 and 450 in 2002 (Sabater 2002), 115 in 2003 and 868 in 2006; in 2013, adults numbered 525.

The population declined from the 2,136 individuals recorded in June 1981 and, after 30 years of fluctuation, only returned to this order of magnitude in May 2011. It was absent in 1998 and 1999 but present in fluctuating numbers every year since 2000. The species is present from late April to early November, breeding mainly from May to August, although more than 300 juveniles were recorded in late October 2009 (Table 5, Figure 6).

Table 4. Sooty Tern 1981–2013. Maximum spring counts of adults and eggs/pulli per year.

	1981	1991	1993	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Adults	5,035	1,660	11	910	3,570	28	6,500	3,450	6,224	2,123	2	1,200	3,500	7,920	1,500	3,800	2,700	10,866	6,335	6,359	3,771
Eggs/pulli	2,500	830	0	455	1,625	0	3,393	384	516	366	0	9	1,750	3,960	521	2	849	5,515	2,665	1,534	1,404

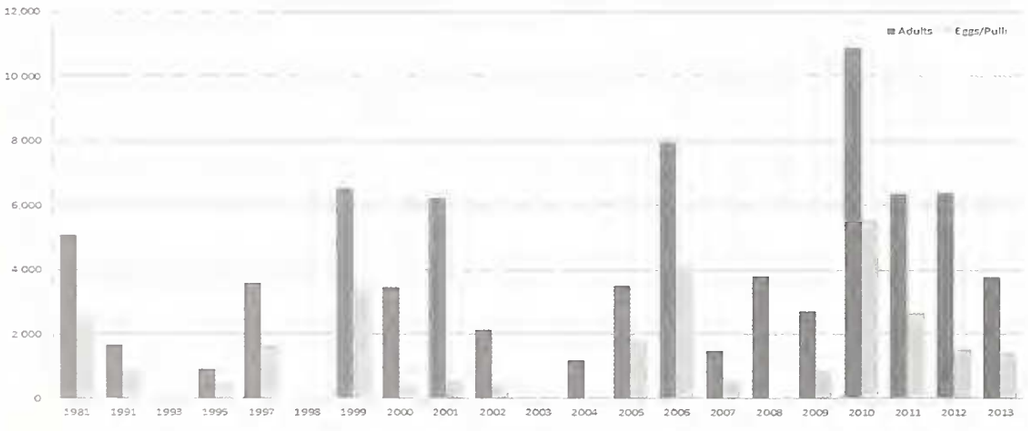


Figure 5. Sooty Tern population and highest numbers of eggs/pulli 1981–2013.

Other Philippine breeding sites: in the Sulu Sea the species is restricted to Maender Reef, Palawan, where 90 adults (six pairs with nests) were recorded on 19 May 2007 (Jensen 2007). Photographic documentation and interviews with navy personnel indicate that more than 300 individuals breed on Lawak Island, Kalayaan Islands, from February (A. Arca pers. comm. 2006, P. Aliño *in litt.* 2009). It may breed on Manlanat (Lantao) Island, Jomalig, Quezon (J. C. T. Gonzalez *in litt.* 2002).

Black Noddy *Anous minutus*

The subspecies *worcesteri*, first found on 24 September 1910 on Cawili Island, Cagayancillo, Palawan (Worcester 1911), now breeds on Tubbataha Reefs. The first record was of 147 adults on South Islet in June 1981 (Kennedy 1982); birds were also present there but did not breed in 1993 and 1999. However, it bred on South Islet in small numbers between 2000 and 2002 and started breeding there again from October 2005, when 215 adults were counted; numbers then rose from 3,300 in 2006 to 8,250 in 2013. The species was first documented on Bird Islet in May 1991 (Palaganas & Perez 1993), when large numbers were breeding in the lettuce trees and where, in October 1991, Heegaard & Jensen (1992) counted 1,503 nests with almost fully-fledged juveniles, equating to about 3,000 breeding adults. In May 1993 Magsalay & Toledo (1993) recorded a total of 2,230 adults, the majority of which were breeding on Bird Islet. In June 1995 Manamtam (1996) found 3,564 nests on Bird Islet, containing 713 pulli and 1,070 eggs—equivalent to a population of 7,128 adults. The Bird Islet population then fluctuated between 3,250 and 4,552 in the period 1997–2000 before about 7,000 were recorded in 2001, although it then collapsed to about 800 in 2004. In 2005 most of the breeding population were still on Bird Islet (6,400 adults) but thereafter the Bird Islet breeding population declined, probably due to loss of habitat—only about 2,500 adults were present there in May 2013. As numbers declined on Bird Islet, those on South Islet increased correspondingly—215 in October 2005, 3,300 in 2006 and 8,250 in 2013, when a record number of 10,656 adults were counted in May on both islets (Table 6, Figure 7).

The Black Noddy breeds mainly from late April to August and, in 1991, 1997, 2008 and 2009, also bred from September to October; it is normally absent from Tubbahata Reefs between November and March. The October breeding population is the smaller of the two, with peak counts of 3,500 individuals in October 1997 and 2,700 individuals in October 2009. Based on peak counts of the two breeding populations, the total annual population is estimated to be between 12,000 and 13,000 adults.

Other Philippine breeding sites: the only other known breeding site is Cawili Island, Cagayancillo (Kennedy *et al.* 2000). According to a resident who had lived on the island since 1959, the species abruptly disappeared in 1987 (W. Dosong pers.comm. 2007).

Eurasian Tree Sparrow *Passer montanus*

First recorded from Bird Islet on 25 October 1991 (Heegaard & Jensen 1992); six to eight birds now breed there annually. Recorded

Table 5. Brown Noddy 1981–2013. Maximum counts of adults and nests per year.

	1981	1991	1993	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Adults	2,136	90	215	643	175	0	0	500	37	775	115	336	834	1,228	750	860	1,570	1,775	2,042	1,492	1,688
Nests	518	0	0	20	54	0	0	83	11	134	45	115	75	416	56	334	384	655	924	709	771

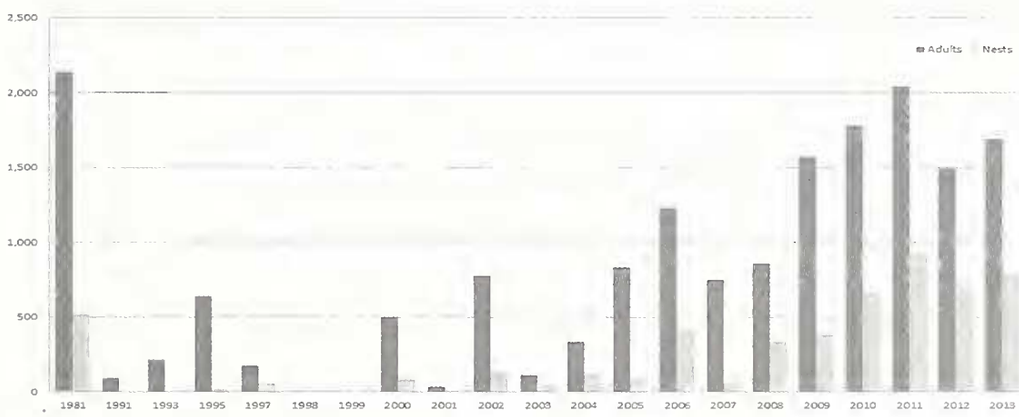


Figure 6. Brown Noddy population and highest numbers of nests 1981–2013.

Table 6. Black Noddy 1981–2013. Maximum counts of adults and nests per year.

	1981	1991	1993	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Adults	147	3,006	2,230	7,128	3,500	3,250	3,850	4,552	6,998	4,860	1,500	805	6,619	7,620	6,250	6,890	7,305	7,644	8,351	9,436	10,656
Nests	Present	1,503	Present	3,564	1,023	901	1,564	863	1,876	1,615	0	208	3,374	3,700	2,718	1,824	2,680	3,525	3,827	4,282	5,156

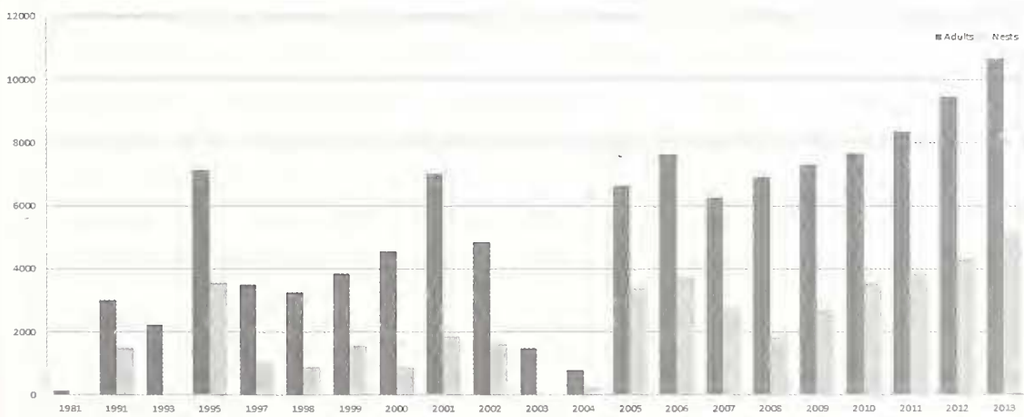


Figure 7. Black Noddy population and highest numbers of nests 1981–2013.

on South Islet since 2010, with up to eight individuals present. The species also occurs irregularly at the Ranger Station.

Other species of particular interest

* Northern Shoveler *Spatula clypeata*

One record, from the Ranger Station on 26 October 2006 (WBCP 2006). An uncommon migrant to the Philippines in suitable habitats (Kennedy *et al.* 2000).

White-tailed Tropicbird *Phaethon lepturus*

One record, an adult between North Atoll and Jessie Beazley Reef, 1 May 2006. An apricot tinge on the elongated tail feathers, lower belly and undertail-coverts, suggested subspecies *dorothea*, although *fulvus* could not be ruled out. The seven Philippine records include one from Palawan, on 19 June 1995 at Sultana Shoal, Cagayancillo (Manamtam 1996, WBCP 2008, 2012). The species, widespread in the Pacific, is considered to be accidental in the Philippines (Kennedy *et al.* 2000).

* Buff-banded Rail *Hypotaenidia philippensis*

One record from Bird Islet, 14 May 2010, and one other Palawan record from Coron Island, 16 February 2009 (WBCP 2009). The species is a locally common resident in other parts of the Philippines (Kennedy *et al.* 2000).

† Swinhoe's Storm Petrel *Hydrobates monorhis* (NT)

The first Philippine record of this Near Threatened species, on 11 May 2013, involved a bird at sea (9.136°N 119.614°E), 20 km west-north-west of Jessie Beazley Reef (Jensen *et al.* 2015). The species breeds as close as on small islets off Taiwan and over-winters in the Indian Ocean (Birdlife International 2015). It is likely that it is regular although perhaps rare or uncommon in Philippine waters.

* Wedge-tailed Shearwater *Ardena pacifica*

First record, one at sea off South Islet, 24 October 1991 (Heegaard & Jensen 1992). There are four subsequent records from the park: an undated 1995 record (Manamtam 1996); one near Jessie Beazley Reef, 11 May 2005; one injured bird on Bird Islet, 27–29 October 2007; and one over the open sea off North Atoll, 6 May 2008. Other records from Palawan province include an unpublished record of one 25 nautical miles off Palawan, 26 June 1980 (Gast 1999), one off Cagayancillo Island, 6 May 2007, and one near Calusa Island, Cagayancillo, 8 May 2008 (WBCP 2007, 2008). Although considered to be an accidental, rare pelagic species (Kennedy *et al.* 2000), more than 100 records since 2004, e.g. from Cagayan and Surigao provinces, suggest that, although uncommon, it is a regular migrant to the Philippines (Allen *et al.* 2006, WBCP 2010, P. Bourdin *in litt.* 2013).

Japanese Night Heron *Gorsachius goisagi* (EN)

One record of this Endangered species from South Islet, 10 May 2005, an adult found dead (Jensen 2005). The following measurements were taken: bill: 44 mm, tarsus: 66 mm, wing: 267 mm. Rare migrant recorded from north, central and south Philippines, including Palawan (Kennedy *et al.* 2000).

* Black-crowned Night Heron *Nycticorax nycticorax*

One record, an immature bird at the Ranger Station, 15 May 2010. There is an unpublished record from Santa Lourdes Beach, Puerto Princesa, Palawan, on 17 May 1980 (Gast 1999), and an immature bird was on Bancoran Island, Mapun, Tawi-Tawi province, on 19 May 2007 (A. Manamtam *in litt.* 2007). Although listed as migratory (Dickinson *et al.* 1991, Kennedy *et al.* 2000), since 2003 breeding colonies have been documented, e.g. Baras Bird Sanctuary, Sultan Kudarat, Mindanao; Paranaque City, Metro Manila; San Simon and Candaba, Pampanga, Luzon; and the Hundred Islands National Park, Pangasinan, Luzon (WBCP 2003, 2004, 2007, 2008, 2009, 2012).

Chinese Egret *Egretta eulophotes* (VU)

First recorded from Bird Islet on 23 March 1995 (Manamtam 1996). There were eight subsequent records of up to three birds, between April 2006 and May 2012. Sixteen individuals were recorded on Bird Islet, two at the Ranger Station, and one on South Islet. A rare migrant in the Philippines, recorded in declining numbers, with most records from the Visayas, central Philippines (Kennedy *et al.* 2000, DENR-PAWB 2012).

Great Frigatebird *Fregata minor*

The species is listed for Bird and South Islets of Tubbataha Reefs by Kennedy *et al.* (2000) but without further details. There are no records of the species in Kennedy (1982). A 1995 record is undated (Manamtam 1996).

Bird Islet: the first dated record was of six adults and one immature, 5 May 2001 (Sabater 2002). Since then the species has been recorded throughout the year, with peak counts of 28 adults and two immature birds on 10 June 2002 and 21 adults and 7 immatures on 8 May 2005. Numbers had fallen to just five adults in 2013, apparently due to the decline and subsequent disappearance of tall trees used for roosting.

South Islet: not recorded before 2011. On 8 May 2013, 13 adults and three immature birds were observed. The appearance of the species here may be associated with kleptoparasitism of the newly established colony of Red-footed Booby and the presence of tall trees suitable for night roosts.

The species's resident status in the Philippines is based on a historical claimed breeding record from Cawili Island, Cagayancillo, Palawan (Worcester 1911). Worcester did not find nests or eggs but based his conclusion on the presence of immature birds and some males with puffed-out scarlet pouches. He wrote, 'the species apparently had finished nesting but immature birds were present in large numbers', and recommended a visit to Cawili Island 'in the season where possibly the frigate birds would be found mating'. According to Wilfredo Dosong (pers. comm. 2007), a resident of Cawili Island since 1959, the species had not bred on the island in his time, although both immature and adult birds were present throughout the year. At the country's largest known frigatebird roost, on Bancauan Island, Mapun, Tawi-Tawi, the senior caretaker claimed that in around 1985 the species bred from December onwards. However, despite a search for nests and other evidence of breeding on 17–19 October 2004 and 16 May 2007, no nesting birds or nests were found (Jensen 2004b, 2007). In the absence of confirmatory data, it appears more likely that the species is migratory, with the main distribution in the Sulu Sea. Frigatebirds are biennial breeders—young birds are dependent on adults for more than a year—hence the year-round presence of adults at Tubbataha Reefs and elsewhere in the Sulu Sea should not be taken as indicative of local breeding. The majority of records on both Cawili and Bancuan Islands are of immatures (Jensen 2004b, 2007), suggesting that these birds are present in the Philippines until they reach maturity.

* Christmas Frigatebird *Fregata andrewsi* (CR)

Only recently confirmed for the Philippines, the species has been seen only in the Sulu Sea (Jensen & Tan 2010), except for one record, 22 January 2013, La Mesa Dam, Quezon City, Metro Manila (Jensen *et al.* 2015). In the Sulu Sea it has been documented from five Philippine islets and eight adjacent islands and islets off Sabah, Malaysia (Jensen 2007). Bancauan Island, Mapun, Tawi-Tawi, where up to 70 birds, both juveniles and adults, have been observed, is an important roost site (Jensen 2004b, 2007, Jensen & Tan 2010). Frigatebirds normally congregate in the greatest numbers just before

dusk; juvenile Christmas Frigatebirds may consequently have been overlooked in mixed frigatebird flocks.

First record from Bird Islet, 5 May 2003, an adult female and a juvenile (Norwin Abes *in litt.* 2004). There were 29 records between May 2003 and May 2013: 16 adults (15 females and one male), ten immatures (3 males and 7 female) and only three juveniles, estimated to be one to two years old, have been identified (Jensen & Tan 2010, Jensen 2011, 2012).

Eurasian Curlew *Numenius arquata* (NT)
One record from Bird Islet, 26 October 1991, comprised four birds (Heegaard & Jensen 1992). Locally uncommon migrant, recorded from north, central and south Philippines, including Palawan (Kennedy *et al.* 2000).

*** Black-tailed Godwit *Limosa limosa* (NT)**
First record of 11 birds on 26 October 1991 (Heegaard & Jensen 1992), then one on 28 October 2006 and one on 7 May 2008 (all from Bird Islet). A rather rare and local migrant in the north and central Philippines, there are internationally important roost sites of this Near Threatened species on Negros Occidental and Cebu (Kennedy *et al.* 2000, DENR-PAWB 2012).

*** Bar-tailed Godwit *Limosa lapponica***
One record of three birds from Bird Islet, 26 October 1991, and one there, 7 May 2008. According to Kennedy *et al.* (2000), the species is an uncommon migrant in the Philippines.

*** Red Knot *Calidris canutus***
One record from Bird Islet, 26 October 1991. According to Kennedy *et al.* (2000), the species is an uncommon migrant in the Philippines.

*** Sanderling *Calidris alba***
Three records from Bird Islet, on 29 April 2006, 7 May 2007 and 8 May 2011, and one from South Islet on 30 April 2006. Four other Palawan records: three birds, Pandan Island, Honda Bay, Puerto Princesa and one, Sabang Beach, Puerto Princesa, in April 2008 (WBCP 2008); one bird, Manamoc Island, Cuyo Archipelago, 23 April 2010 (WBCP 2010); and one, Arreceffi Island, Honda Bay, Puerto Princesa, 12 November 2011 (WBCP 2011). The species is an uncommon migrant to the Philippines (Kennedy *et al.* 2000).

Grey-tailed Tattler *Tringa brevipes* (NT)
Eighteen counts, one in October 1991 and 17 between 1999 and 2013, recorded 502 individuals— 412 from Bird Islet and 90 from South Islet. Fourteen of the counts were made in April–May, one in March, one in September and two in October. Most sightings occurred during southwards migration, with a peak count of 237 birds in October 1991. Peak counts during northwards migration were 43 birds in both March 1991 and May 2004.

The average numbers of birds counted, arranged in 5-year intervals between 1999 and 2013, shows a declining trend: 21 individuals annually in 1999–2003, 17 annually in 2004–2008, and just two annually in 2009–2013. The number of birds during the southward migration dropped from 237 individuals in October 1991 to 65 in September 2000 and just eight in October 2006.

Recent evidence suggests that the global population of the species declined between 1987 and 2011 and it is currently listed as Near Threatened, due to an estimated overall decline of 20–29% in Australia over the last 25 years (van Gils & Wiersma 2014). Numbers migrating through Japan in autumn have declined by 57% between 1983 and 2007 (Amano *et al.* 2010).

Ruddy Turnstone *Arenaria interpres*
The earliest counts are from October 1991 and March 1995. The species has been recorded in every year from 1997 to 2013, with 25 counts made: two in January, one in March, two in April, 14 in May, one in August, three in October and two in November. The counts resulted in a total of 870 birds, of which 691 were recorded on Bird Islet and 179 on South Islet. Most birds were seen during southward migration, with a peak count of 174 individuals in October 1991. The highest count during northward migration was 95 in March and a winter high count of 47 occurred in January 2006.

The average number of birds counted in April and May, arranged in 5-year intervals between 1999 and 2013, was 24 individuals annually for the decade 1999 to 2008. However, the average for 2009 to 2013 was only five birds annually. The number of birds during the southward migration period dropped from 174 in October 1991 to 94 in October 2006. Although the data are limited, they suggest either a change in migration phenology or that the population over-wintering in and transmigrating through Tubbataha Reefs is undergoing a decline

*** Pomarine Skua *Stercorarius pomarinus***
One record of a light phase adult passing South Atoll on 10 May 2005. A bird passing North Atoll on 8 May 2009 may have been this species. Additional records from the Sulu Sea include one at Manuc Manucan Reef (7.717°N 118.450°E), Mapun, Tawi-Tawi, 21 October 2004 (WBCP 2004); two between Cagayancillo and Cawili Islands, Cagayancillo, Palawan, 6 May 2007 (WBCP 2007); and up to 50 off Patikul (6.089°N 121.105°E), Jolo Island, Sulu, 19 December 2012 (WBCP 2012). Although listed as a rare migrant (Kennedy *et al.* 2000), records since 2004 confirm that the species occurs annually in the Philippines (WBCP 2004, 2005, 2008, 2010, 2011, 2012).

*** White-throated Kingfisher *Halcyon gularis***
One record from South Islet of a single taken by a Peregrine Falcon *Falco peregrinus*, 30 April 2006. The species is a fairly common resident in the Philippines (Kennedy *et al.* 2000).

*** Oriental Skylark *Alauda gulgula***
One record of a bird passing northwards at the Ranger Station, 8 May 2005. An uncommon resident in the Philippines, but no information about inter-island movement (Kennedy *et al.* 2000).

*** Clamorous Reed Warbler *Acrocephalus stentoreus***
One individual was caught in a mist-net on South Islet, 10 May 2005, and released the same day. It is an uncommon resident in the Philippines, but there is no information about inter-island movement (Kennedy *et al.* 2000).

Purple-backed Starling *Agropsar sturninus*
One record from Bird Islet, 26 October 1991, two birds observed (Heegaard & Jensen 1992); the second of only three Philippine records (Jensen *et al.* 2015).

† Rosy Starling *Pastor roseus*
First Philippines record from South Islet, 10 May 2009, one adult in non-breeding plumage. Two subsequent records (Jensen *et al.* 2015).

Yellow Wagtail *Motacilla flava*
A male of subspecies *macronyx* on Bird Islet, 7 May 2005, was the first record of this taxon from the Philippines (Jensen 2005). It was identified by its uniform grey crown and ear-coverts, the absence of a supercilium, green upper back, bright yellow underparts and distinctive whitish wing-bars. Subspecies *macronyx* breeds from Transbaikalia, Amurland and Ussuriland, Far East Russia to Mongolia, Manchuria and China and winters in South-East Asia and south-east China (Tyler *et al.* 2016).

A male *tschutschensis* Yellow Wagtail recorded on Bird Islet on 14 May 2010 was the first Philippines record of this taxon, and

another male was there, 9–10 May 2013 (Jensen 2010, 2013). The bird showed a pale grey head, blackish ear-coverts and a long white supercilium. Subspecies *tschutschensis* breeds from north-east Siberia to the most easterly parts of north-eastern Russia and western and northern parts of Alaska, and winters mainly in South-East Asia south to most of the Indonesian islands (Tyler *et al.* 2016).

DISCUSSION

Changes to land area

Bird Islet (formerly known as North Islet) has undergone major changes since June 1911, when it was a 'low flat sandy island some 400 meters long by 150 wide' (Worcester 1911); by 1981 it was described as 268 m long and 70 m wide at high tide (Kennedy 1982). The area of the islet has decreased from an estimated 60,000 m^2 in 1911, to 18,760 m^2 in 1981, 17,000 m^2 in 2004 and about 10,930 m^2 in 2013 (Jensen 2013). After a change of only 9% between 1981 and 2004, the following 10 years to 2013 saw a further 35% reduction—blocks of the sandstone, with surface soil, up to 1 m^2 in area, are now broken off the islet by wave action during high tides or stormy weather (Plate 4). This severe erosion has seriously damaged the south and north-west shorelines and reduced the area available to the ground-nesting boobies (Kennedy 1982, Jensen 2006).

South Islet, in contrast, is relatively stable due to the concrete seawall constructed in 1978, although an adjacent wide barren sandbar, which hosted dense tern colonies in 1981 (Kennedy 1982) has disappeared. Other changes in land area include the disappearance of an unnamed sandy islet at Black Rock on the South Atoll (Worcester 1911, Kennedy 1982).

Global sea-levels rose at a mean rate of 1.8 mm per year for the past century (Douglas 1997, Church & White 2006); however, between 1993 and 2003 rates have been estimated to be 2.8–3.1 mm per year (Bindoff *et al.* 2007). Since 1990, the number of tropical cyclones in the west Pacific has increased, although the number of resulting typhoons making landfall on the Philippines has remained constant at about 20 per year. However, the typhoon path, intensity and duration have changed—today more typhoons make landfall on the central Philippines and also impact the previously relatively typhoon-free Sulu Sea (Emmanuel 2007). The rise in sea-level, together with the increased frequency and intensity of storms crossing the Sulu Sea, appear to be the main factors that are causing the changes in land area. Changes in sea currents are a contributory factor, causing major movements of sand deposits, which have led to the emergence of numerous temporary sand cays in the reef flats of the atolls, the disappearance of the major sandbars at Black Rock and around South Islet and, between 2008 and 2010, a substantial decrease in the area of a major sandbar adjoining Bird Islet (Kennedy 1982, Aquino *et al.* 2011, Jensen 2013).

Plate 4. Bird Islet, 9 May 2013. Erosion has caused a decrease in land area of more than 40% since 1981.

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Habitat changes

Both Bird and South Islets have changed progressively from barren to fully-vegetated habitats, influencing the make-up of breeding bird species. The vegetation is now predominantly lettuce tree *Pisonia alba* and octopus bush *Argusia argentea* with tropical almond *Terminalia catappa*, and a few stands of coconut palm *Cocos nucifera*. Butter daisy *Melampodium divaricatum*, purslane *Portulaca oleracea*, purple-top chloris *Chloris inflata* and *Setagaria geniculata* also occur (Kennedy 1982, Palaganas & Perez 1993, Jensen 2007).

In 1911, Bird Islet was barren, except for a few stands of purslane (Worcester 1911), and remained so for the next 70 years (Kennedy 1982). By 1991 dense young beach-forest with more than 100 trees had developed on the north, east and south-east shorelines (Heegaard & Jensen 1992); bush and tree numbers increased to about 500—many up to 9 m tall—by 2004. However, since then the massive influx of breeding Red-footed Boobies has destroyed this habitat; by 2013 nearly all mature trees were dead and bushy vegetation was deteriorating due to the activities of this species (Jensen 2013). The destruction of vegetative cover by Red-footed Boobies caused most of the Black Noddies, which had nested in the lettuce trees since 1991, to move to South Islet (Jensen 2013). On Bird Islet in 1991 there was an 8,000 m^2 open grassy area known as 'the Plaza' (Heegaard & Jensen 1992), which was the historical breeding site of ground-nesting seabirds. By 2002 it had been reduced to only about 1,100 m^2 by the rapid spread of introduced tamarind *Leucaena leucocephala* (White *et al.* 2004). In 2007 tamarind was eradicated by the park staff and the Plaza (Plate 5) has expanded to 4,840 m^2 (Jensen 2013). Species which use trees for night roosts, such as frigatebirds, including the Critically Endangered Christmas Frigatebird, have benefited from the increased vegetative cover. Conversely, the increased vegetative cover that resulted from the building of the seawall on South Islet when the lighthouse was built in 1978 may have contributed to the decline and subsequent disappearance of the ground-breeding Greater Crested Tern and Sooty Tern from that location. South Islet was largely barren in 1981, apart from a few bushes (Kennedy 1982). In 1991 Heegaard & Jensen (1992) found considerable native beach-forest vegetation with relatively tall trees with thick foliage, together with dense bushy vegetation (Plate 6). In 2013 there were about 130 trees, although since 2011 the condition of nearly half of them has deteriorated due to the presence of breeding Red-footed Boobies (Jensen 2013).

Changes in the breeding seabird population

The park is the only known breeding area of the subspecies *worcesteri* of the Black Noddy. This taxon formerly bred on Cawili Island until 1987 and may also occur on Ashmore Reef, north-west Australia (Gochfeld *et al.* 2016). Within the Philippines it hosts the only major colony of Brown Booby, the second-largest populations of

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Plate 5. Bird Islet, May 2013. The main breeding ground for Brown Booby *Sula leucogaster* and Greater Crested Tern *Thalasseus bergii* at the Plaza. In the background are dead trees killed by the high breeding density of Red-footed Booby *Sula sula*.

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Plate 6. South Islet, 8 May 2013. Dense vegetation with breeding Black Noddy *Anous minutus*.

Red-footed Booby and Sooty Tern, and the largest breeding colonies of Greater Crested Tern and Brown Noddy.

Using the count results from June 1981 (Kennedy 1982) as a baseline to determine variations and trends over time, it can be concluded that there have been considerable changes in the seabird populations of the park. The number of breeding seabird species declined from seven in 1981 to six by 1995 and the ranking of the three most abundant species in 1981—Sooty Tern (5,070), Brown Booby (3,768) and Greater Crested Tern (2,264)—changed over the period to 2013 to Black Noddy (10,656), Greater Crested Tern (10,500) and Sooty Tern (3,771).

From about 13,540 adults of all species in 1981, the breeding population decreased to about 5,450 in 1991, a 60% decline. It increased to more than 11,000 in 1995 before again declining to only about 4,990 in 1998. Between 1999 and 2002 the average breeding population increased to 12,460 individuals but in 2003 the population was just 4,320 individuals, less than a third of Kennedy's count in 1981. However, since 2004 there has been a gradual population increase to an all-time high of about 32,300 individuals in 2012 and 2013, 138% higher than the first count of 1981 (Figure 8).

There are significant differences in the population trends of tree-nesting and ground-nesting seabirds. The population of ground-nesting species in 2013 was 35% higher than in 1981. This is due to an increase in the Greater Crested Tern population from about 2,260 individuals in 1981 to nearly 10,500 in 2013. Other species had lower populations in 2013 than in 1981: the Brown Booby population (2,155) is 43% lower and the Brown Noddy population (1,688) is 21% lower. The Masked Booby population declined rapidly in the 1970s and by 1981 numbered only 150 adults; it was extirpated from Tubbataha Reefs Natural Park, and the Philippines, in 1995.

Because of the growth of suitable habitats for the tree-nesting Black Noddy and Red-footed Booby, these two species have undergone a remarkable increase: from only 147 Black Noddies in 1981 to about 10,650 in 2013, and from just six breeding Red-footed Boobies in 2002 to about 4,490 in 2012. It is probable that the Black Noddy population originated from Cawili Island, from where it disappeared abruptly in 1987 (W. Dosong pers. comm. 2007). A large number of fishermen settled on Cawili Island from 1975 to 1977, increasing the killing of seabirds and converting most of the beach-forest on the island to agricultural lands (Arquiza & White 1999), which may explain the species's disappearance from Cawili Island and the corresponding breeding in large numbers on Tubbataha Reefs (Palaganas & Perez 1993).

There have been considerable fluctuations between some years in the breeding numbers of Greater Crested Tern, Sooty Tern and Brown Noddy. There was an apparent absence of these species in 1998, of Greater Crested and Brown Noddy in 1999, and of Sooty Tern again in 2003, whilst in some years there are unusually high breeding numbers of Greater Crested Tern (2005–2006 and 2012–2013) and of Sooty Tern (1999, 2001, 2006, 2010 and 2012). These population peaks could indicate irregular population trends which may be associated with sea-surface temperature variations, as concluded by Devney *et al.* (2009). They found that population declines of pelagic seabirds were related to the frequency and intensity of El Niño anomalies in the western tropical Pacific.

There have been eight moderate to strong El Niño and four La Niña events since seabird data collection started at Tubbataha Reefs in 1981 (Null 2014, WMO 2014). The absence of breeding Greater Crested Terns and Brown Noddies in 1998 to 1999 and of Sooty Terns in 1998 coincides with the El Niño/La Niña anomalies in

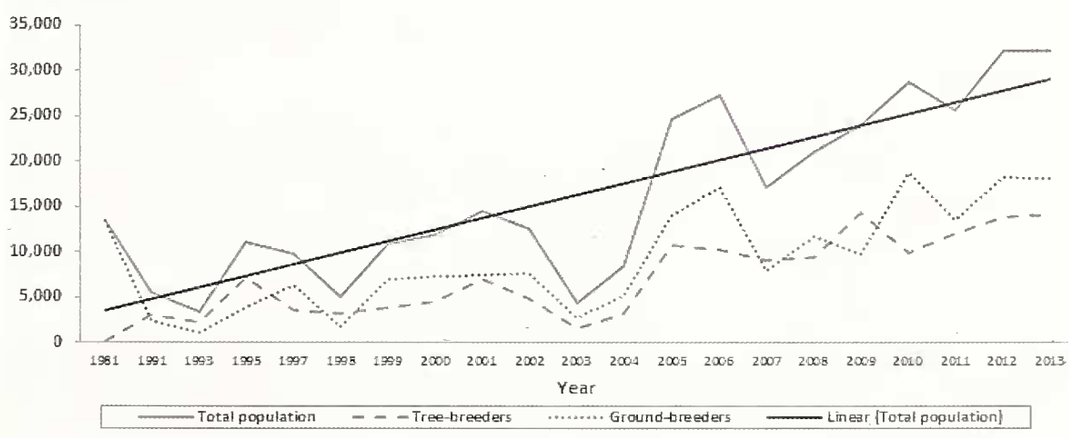

Figure 8. Breeding seabird population trends in Tubbataha Reefs Natural Park 1981–2013.

1997 to 1999, while an El Niño period in 2002 to 2003 coincided with the absence of Sooty Terns in 2003.

Devney *et al.* (2009) showed that El Niño generated sea-surface temperature anomalies and 'intense El Niño events can severely impact seabird populations, often months in advance of peak temperature anomalies'. Recent phenological analysis of seabird data from Tubbataha Reefs by Carcallas (2013) suggests that the higher the chlorophyll concentration, which occurred in January to March, the earlier the Sooty Terns start egg-laying, while the peak sea-surface temperature was strongly linked to the start of egg-laying for the Greater Crested Tern. However, the overall increase in the sea-surface temperature did not negatively influence the adult seabird population in the park over time.

Factors affecting the seabird population

Negative anthropogenic factors affecting seabirds included the seasonal collection of eggs and chicks and frequent disturbance of the breeding colonies by visiting fishermen and scuba divers up to 1998, when the islets were closed to visitors. Park staff have documented a growing number of avian casualties caused by marine debris, which may cause many fatalities through entanglement in discarded or lost fishing gear and the ingestion of toxic chemicals from degrading plastics (Pierce *et al.* 2004, Gregory 2009, Eidt 2012, Lavers & Hutton 2014). In Tubbataha Reefs Natural Park marine flotsam, particularly plastic, is increasingly used as nesting material by seabirds. Other factors affecting seabirds include climate-change related variations in sea-surface temperature, changes in severity and movement patterns of typhoons, and a rise in sea-level, causing breeding failure and reducing the area available to birds for breeding.

Both Worcester (1911) and Kennedy (1981) encountered egg-collectors during their brief visits. Many fishing crews survived on fish, birds and their eggs taken from Tubbataha Reefs, while commercial dive-boat crews were observed with drums full of seabird eggs (Kennedy 1982, Arquiza & White 1999). The frequency of disturbance and egg collection by visiting divers and fishermen intensified during periods of good weather from March to May and in October. Heegaard & Jensen (1992) found 25 fishing vessels from Cagayancillo, Cebu and Taiwan anchored around Bird Islet in October 1991, with nearly 80 people in and around the breeding seabird colony, evidently causing disturbance.

The seabird population trends correlate well with the intensity of anthropogenic pressures. By 1998, when the no-visitor policy was enforced, the Brown Booby population had declined by over 50% since the 1981 count by Kennedy (1982) and 'lag effects' probably caused the decline to continue to 85% by 2002; since then there has been a slow increase, although it is still about 43% lower than in 1981. Today the park's Bird and South Islets may be the only Sulu Sea islets which continue to be free of human-introduced predators and from human disturbance (Jensen 2007).

Bird Islet has an altitude of 1.5–2 m (Kennedy 1982); a reduction in area, particularly of the lower-lying Brown Booby breeding area on the Plaza, has caused this species to move its breeding area onto higher ground. Upper-level projections for sea-level rise to the end of the twenty-first century are up to 1 m above current levels (Gregory 2013). A rise in sea-level of this magnitude would reduce the area of the islet from about 11,000 m^2 to an estimated 5,000 m^2, a major reduction in available breeding area, probably leading to a reduction in the population of Brown Booby and ground-nesting tern species.

The population dynamics of the seabirds of the Tubbataha Reefs is complex, and requires further research: there are no studies of the reproduction and survival rates of Philippine seabirds; dispersal of the juvenile and adult populations outside the breeding period is also unknown; and the impact of marine debris on the park's seabirds is yet to be documented. The presence of protected seabird colonies in Tubbataha Reefs Natural Park provides opportunities for avifaunal research that could fill gaps in our knowledge and further enhance the effective conservation and management of seabirds.

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Appendix 1

Annotated list of the birds of Tubbataha Reefs Natural Park

Key: † = new records for the Philippines, * = species not listed for Palawan province by Dickinson *et al.* (1991) or Kennedy *et al.* (2000).
Area = location of records in Tubbataha Reefs Natural Park: B = Bird Islet, S = South Islet, RS = Ranger Station, A = Amos Rock, J = Jessie Beazley Reef, P = pelagic.
Status in Philippines, based on Kennedy *et al.* (2000): M = Migrant, R = Resident.
Occurrence in Philippines, based on Kennedy *et al.* (2000): Ex = Extirpated, Ra = Rare, LU = Locally Uncommon, U = Uncommon, LC = Locally Common, FC = Fairly Common, C = Common.
No. = total number of birds seen.

Species	Area	Status	Occ	First record	Subsequent records and years	No.	Notes
* Northern Shoveler *Spatula clypeata*	RS	M	U	26/10/2006		1	
White-tailed Tropicbird *Phaethon lepturus*	P	M	Ra	1/5/2006		1	
Grey Nightjar *Caprimulgus jotaka*	S	M	Ra	7/5/2007	1: 2008	2	
Uniform Swiftlet *Aerodramus vanikorensis*	J	R	C	1/5/2006		12	
Edible-nest Swiftlet *Aerodramus fuciphagus*	B	R	U	10/5/2013		1	
Pacific Swift *Apus pacificus*	B	M, R	U	5/5/2003		4	
Oriental Cuckoo *Cuculus saturatus*	B, S	M	U	6/5/2004	2: 2006, 2007	4	
Brush Cuckoo *Cacomantis variolosus*	B	R	C	26/10/1991		1	
Red-legged Crake *Rallina fasciata*	B, S	R?, M?	Ra	26/5/2002	2: 2010, 2012	3	Records include two found dead in May
Slaty-legged Crake *Rallina eurizonoides*	S	R	U	6/5/2004	1: 2008	3	All found dead in May
* Barred Rail *Hypataenidia torquata*	B, S	R	C	5/5/2003		27	Breeding population in 2013: 2
* Buff-banded Rail *Hypataenidia philippensis*	B	R	LC	14/5/2010		1	
Slaty-breasted Rail *Lewinia striata*	S	R	U	7/5/2004	1: 2013	3	
White-breasted Waterhen *Amaurornis phaenicurus*	B	R	C	5/5/2003		1	
Baillon's Crake *Zapornia pusilla*	B	M	U	9/5/2005		1	
Watercock *Gallicrex cinerea*	S	R	FC	8/5/2013		1	
Common Moorhen *Gallinula chloropus*	S	M, R	C	24/10/1991		1	
† Swinhoe's Storm Petrel *Hydrobates monorhis*	P	M		11/5/2013		1	First country record (Jensen *et al.* 2015)
Bulwer's Petrel *Bulweria bulwerii*	P	M	Ra	1/5/2006	2: 2008, 2013	3	
* Wedge-tailed Shearwater *Ardenna pacifica*	P	M	LU	24/10/1991	3: 2005, 2007, 2008	4	
Yellow Bittern *Ixobrychus sinensis*	B, S	R	C	26/10/1991	1: 2005	2	
Cinnamon Bittern *Ixobrychus cinnamomeus*	B, S	R	C	6/6/2002	1: 2002	3	
Japanese Night Heron *Garsachius goisagi*	S	M	Ra	10/5/2005		1	Found dead. See species account
* Black-crowned Night Heron *Nycticorax nycticorax*	RS	R	LU	15/5/2010		1	
Green-backed Heron *Butarides striata*	B, S, RS	M, R	FC	6/5/2004	5: 2005–2007, 2012–2013	7	
Cattle Egret *Bubulcus alba*	B, S, RS	M, R	LC	26/10/1991	8: 2005–2006, 2009–2010, 2012–2013	23	
Grey Heron *Ardea cinerea*	B, S	M	U	26/5/2002	3: 2002, 2006	21	
Great-billed Heron *Ardea sumatrana*	S	R	LU	24/10/1991		1	
Great White Egret *Ardea albus*	B	M, R	U	26/10/1991	3: 2005, 2011, 2012	5	
Intermediate Egret *Ardea intermedia*	*B*	*M*	*LC*	*26/10/1991*	*1: 2005*	*4*	
Little Egret *Egretta garzetta*	B, S	M, R	C	26/10/1991	7: 2005–2007, 2011–2013	13	
Chinese Egret *Egretta eulaphates*	B, S, RS	M	Ra	23/3/1995	8: 2006–2012	21	
Pacific Reef Egret *Egretta sacra*	B, S, RS	R	U	24/10/1991			Breeding population in 2013: 18
Great Frigatebird *Fregata minar*	B, S, J	M	LU	?	21: 1995, 2001–2013	228	See species account
Lesser Frigatebird *Fregata ariel*	B, S, J	M	LU	24/10/1991	16: 2004–2013	63	
* Christmas Frigatebird *Fregata andrewsi*	B, S	M	Ra	5/5/2003	10: 2004–2009, 2011–2012	31	Jensen & Tan 2010

Species	Area	Status	Occ	First record	Subsequent records and years	No.	Notes
Masked Booby *Sula dactylatra*	B	R	Ex?	29/6/1911	6: 1981, 1989, 1991, 1993, 1995	189	Last record 23 June 1995
Red-footed Booby *Sula sula*	B, S, J	R	LC	15/6/1981			Breeding population in 2013: 3,568
Brown Booby *Sula leucogaster*	B, S, J	R	Ra	29/6/1911			Breeding population in 2013: 2,155
Black-winged Stilt *Himantopus himantopus*	RS	M, R	LC	4/2007		1	
Pacific Golden Plover *Pluvialis fulva*	B	M	C	26/10/1991		2	
Grey Plover *Pluvialis squatarala*	B, RS	M	C	26/10/1991	6: 2005–2010, 2012	87	
Kentish Plover *Charadrius alexandrinus*	B	M	C	28/10/2006		1	
Lesser Sand Plover *Charadrius mangalus*	B, S, RS	M	C	24/10/1991	2: 1991, 2004	3	
Greater Sand Plover *Charadrius leschenaultii*	B	M	C	28/4/2006		5	
Whimbrel *Numenius phaeopus*	B, S, RS	M	C	24/10/1991	12: 1991, 1998, 2000, 2002, 2003, 2005, 2006, 2009	94	
Eurasian Curlew *Numenius arquata*	B	M	U	26/10/1991		4	
* Black-tailed Godwit *Limosa limosa*	B	M	Ra	26/10/1991	2: 2006, 2008	13	
* Bar-tailed Godwit *Limosa lapponica*	B	M	U	26/10/1991	1: 2008	4	
* Red Knot *Calidris canutus*	B	M	U	26/10/1991		1	
* Sanderling *Calidris alba*	B, S	M	U	29/4/2006	3: 2006, 2007, 2011	4	
Red-necked Stint *Calidris ruficollis*	B	M	C	26/10/1991		1	
Ruff *Calidris pugnax*	B	M	Ra	26/10/1991		2	
Red-necked Phalarope *Phalaropus lobatus*	B, RS, J	M	C	26/10/1991	5: 2004, 2005, 2008, 2009, 2011	49	
Common Sandpiper *Actitis hypoleucos*	S	M	C	8/5/2013		2	
Common Greenshank *Tringa nebularia*	B	M	C	26/10/1991	1: 2006	3	
Green Sandpiper *Tringa ochropus*	B	M	Ra	26/10/1991		2	
Wood Sandpiper *Tringa glareola*	B	M	C	28/10/2006	1: 2008	5	
Grey-tailed Tattler *Tringa brevipes*	B, S, RS	M	C	26/10/1991	17: 1991, 2004–2009, 2011–2013	502	Probably declining
Ruddy Turnstone *Arenaria interpres*	B, S, RS	M	FC	13–14/6/1981	25: 1991, 1995, 1997–2013	870	Probably declining
Brown Noddy *Anous stolidus*	B, S, J	R	LU	29/6/1911			Breeding population in 2013: 1,688
Black Noddy *Anous minutus*	B, S, J	R	Ra	15/6/1981			Breeding population in 2013: 10,656
Bridled Tern *Onychoprion anaethetus*	J, P	M, R	Ra	9/5/2009	2: 2010, 2013	10	
Sooty Tern *Onychoprion fuscatus*	B, S, J	M, R	Ra	13/6/1981			Breeding population in 2013: 3,771
Little Tern *Sternula albifrons*	B, S, RS	M, R	U	22/3/1995	3: 2003, 2005, 2006	9	
Whiskered Tern *Chlidonias hybrida*	B, S, J	M	C	26/10/2006	4: 2011–2013	10	
White-winged Tern *Chlidonias leucopterus*	B, S, RS, J, P	M	FC	6/5/2004	14: 2005, 2006, 2009–2013	250	All but one record were of migrating flocks
Greater Crested Tern *Thalasseus bergii*	B, S, RS, J	R	FC	29/6/1911			Breeding population in 2013: 10,500
Roseate Tern *Sterna dougallii*	B, S, RS, A, J	R?	Ra	22/3/1995	5: 1995, 2004–2006, 2012	23	
Black-naped Tern *Sterna sumatrana*	B, RS, A, J	R	U	7/5/2004	10: 2005–2007, 2009–2011, 2013	37	
Common Tern *Sterna hirundo*	B, RS, J	M	U	6/5/2004	3: 2008, 2011, 2013	33	
* Pomarine Skua *Stercorarius pomarinus*	P	M	Ra	10/5/2005			Light phase adult
Brown Boobook *Ninox scutulata*	B, S	M, R	U	15/4/2004	4: 2004–2006, 2013	8	Migrant subspecies *japonica*
Grey-faced Buzzard *Butastur indicus*	B	M	FC	26/10/1991		1	
* Blue-throated Bee-eater *Merops viridis*	B	R	FC	9/5/2005		1	
Ruddy Kingfisher *Halcyon coromanda*	S	M, R	U	10/5/2005		1	Found dead
* White-throated Kingfisher *Halcyon gularis*	S	R	FC	30/4/2006		1	Found dead
Collared Kingfisher *Todiramphus chloris*	B, S	R	C	24/10/1991	13: 1991, 1993, 2000–2006, 2009	25	Two found dead
Common Kingfisher *Alcedo atthis*	B, S	M	C	24/10/1991	3: 1991, 2006	8	
Oriental Hobby *Falco severus*	S	R	U	6/5/2003		1	
Peregrine Falcon *Falco peregrinus*	B, S	M	U	7/5/2004	6: 2004–2007, 2011– 2013	8	All records were of migratory subspecies
Western Hooded Pitta *Pitta sordida*	S	R	C	26/5/2002		1	Found dead
Brown Shrike *Lanius cristatus*	B, S	M	C	24/10/1991	9: 1991, 2004, 2006, 2009, 2011, 2012	20	
Large-billed Crow *Corvus macrorhynchos*	S	R	C	30/4/2006		1	Found dead
Barn Swallow *Hirundo rustica*	B, S	M	C	24/10/1991	6: 1991, 2004, 2006	25	
House Swallow *Hirundo javanica*	B	R	C	28/10/2006		3	
* Oriental Skylark *Alauda gulgula*	RS	R	U	8/5/2005		1	
Lanceolated Warbler *Locustella lanceolata*	B, S	M	U	26/10/1991	2: 2007, 2013	3	
Middendorff's Grasshopper Warbler *Locustella ochotensis*	S	M	U	10/5/2005	1: 2006	2	
Oriental Reed Warbler *Acrocephalus orientalis*	B, S	M	C	24/10/1991	3: 1991, 2005, 2013	8	
* Clamorous Reed Warbler *Acrocephalus stentoreus*	S	R	U	10/5/2005		1	
Arctic Warbler *Phylloscopus borealis*	B, S, RS	M	C	15/10/1991	11: 2003–2006, 2009, 2011, 2012	22	
Purple-backed Starling *Agropsar sturninus*	B	M		26/10/1991		2	Second country record (Jensen *et al.* 2015)
Chestnut-cheeked Starling *Agropsar philippensis*	B	M	U	28/10/2006	1: 2012	4	
† Rosy Starling *Pastor roseus*	S	M		9/5/2009		1	First country record (Jensen *et al.* 2015)
Blue Rock Thrush *Monticola solitarius*	S	M, R	C	29/4/2006		1	
Grey-streaked Flycatcher *Muscicapa griseisticta*	B, S	M	C	26/10/1991	1: 2006	2	
Narcissus Flycatcher *Ficedula narcissina*	S	M	Ra	30/10/2006		1	
Blue-and-white Flycatcher *Cyanoptila cyanomelana*	B	M	Ra	26/10/1991		1	
Eurasian Tree Sparrow *Passer montanus*	B, S,	R	C	25/10/1991			Breeding population in 2013: 16
Forest Wagtail *Dendronanthus indicus*	S	M	Ra	10/5/2005		1	
White Wagtail *Motacilla alba*	B, S	M	Ra	26/5/2002	1: 2009	2	
Yellow Wagtail *Motacilla flava*	B, S, RS	M	C	6/5/2004	14: 2005–2006, 2009–2013	41	See species account
Grey Wagtail *Motacilla cinerea*	B, S, RS	M	C	26/10/1991	13: 2004 – 2006, 2009 – 2011, 2013	26	
Olive-backed Pipit *Anthus hodgsoni*	?	M	U	9/5/2005	6: 2005, 2006, 2011	16	
Pechora Pipit *Anthus gustavi*	B, S	M	U	24/10/1991	6: 1991, 2004, 2005, 2008, 2009	8	